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Idea Longitudinis:

Being, a brief

DEFINITION

Of the best known

AXIOMS

For finding the

Longitude.

A more Rational *Discovery* thereof, than hath been heretofore Published.

By *Edward Harrison*, Lt.

LONDON,
Printed for the Author, and sold by Mr. *Sellers*, at the *Hermitage*; *R. Mount*, at the *Postern*, on *Tower-Hill*; and *P. Lea*, at the *Atlas* and *Hercules* in *Cheapside*, at the Corner of *Friday-street*, 1696.

MVSEVM
BRITAN
NICVM

To the Right Honourable, the Commissioners for Executing the Office of Lord High Admirall of England, &c.

My Lords,

IT is a saying in the *Navy*, He that knows not how to obey *Command*, is not worthy to bear *Command*; and another saying

I have often heard in the *Navy*. It is hard for an Officer to know when he goes too fast or too slow, that is, whether he is too severe in the Execution of his Duty, or too dull or slow; in which Cases, it is sometimes difficult to please our Superiours, because of their different Humours: As it is the Duty of a Subject to be True and Loyal to his Prince, so it is the Duty of Servants, to be Faithful, Humble, and Submissive to their Masters. I thought it my Du-

ty, my Lords, Humbly to present you with this small Treatise, not only as a Servant, but that whereas some part of it may happen to fall under your Construction, more particularly the Chapter concerning *Magnetick Variation*, which I Humbly Commend to your Joynt Care and Consideration, for the Improvement and Encouragement of *Navigation*, and Amendment of Faults in the *Navy*, if I may presume to say there is any Faults there; an Elegant Stile cannot

Reasonably be expected from Sea breeding: I am not willing to seem tedious, if in my Discourse in this Book, you find some small Faults; I hope your Wisdom will be pleased to Pardon, and Excuse them.

I am,

my Lords,

Your most Humble,

and Obedient Servant,

EDWARD HARRISON.

PREFACE

To the Reader.

After Columbus *returned from his Discovery of the Land now called* America, *he happened into Company with some* Spaniards, *who had the Vanity to tell him, that he had done nothing, but what they could do as well as he; Yes, Gentlemen, said he, now I have shown you the way: he called for a Hens Egg, and desired them to make it stand on one end, (without leaning,) on a smooth and flat Table, they all tryed, but none of them could make it so to stand; he*

tryed after them, and made it ſtand, &c. ſo could they alſo, when he had ſhewed them the way: I doubt not but in a ſhort time there will be many Pretenders to the Longitude, *and to underſtand it better then I; be pleaſed to remember that I ſhewed the way (or can if I pleaſe.) Miſtake me not; think not that I am deſigned in this ſmall Treatiſe, to Teach the whole Art of* Longitude; *Art* Mathematick *is very Copious, part of which is Art* Longitude, *Ingenious and Compendious, requiring much larger* Volumes *then this is; I ſay, I can (if I will) God willing, ſhew you the true Principles, the right Radix, and* Baſis, *whereon this Fabrick may be built; yea Man might carry a Stone to St. Pauls Church in* London, *and lay it on the Foun-*

dation,

dation, give Directions for Building the same, but he alone could never have perfected, (as now it almost is,) that Stately and Glorious Edifice; I may begin my work to Day, but what Encouragement I may meet with in carrying it on, I know not; or if it may please God that I may live to see this Art brought to such Perfection, as to be fit for Seamens Practise; some Years ago, I presented a few Lines concerning this Art, to a Nobleman, or Person of Quality, which Lines he little understood, and less regarded; which one of my Friends understanding, well compared to casting Pearl before [redacted]. I have been informed of one who pretended to find the Longitude, and requiring a Gratuity, was sent to Mr.——— to have his

Appro-

Approbation; I think they might as well a sent him to a been Rob'd; I Discoursed this Art with some Fellows of the R. S. whom I found too much aiming at their peculiar Advantage; therefore I resolved to appear on the Publick Stage, in Print, Nevertheless, the Description is a little Veiled, *though it is what I thought convenient to Publish; As for my Stile, I understand not how to Express my Sentences, in* Topical Syllogisms, *or* Sophistical Rhetorick; *if you meet with a plain Method, downright Reasoning, and matter of Purpose, it is what I aim at; I know my Method differs much from other Writers, I write the Truth to the best of my Knowledge, and value not* Carpers, *in spite of Envie, I presume to declare, That I believe there are but* few

few Marriners in England, that understand how to keep an Account of a Ships way on the Sea, as well as I have done, or may do; and if I know more than others, it is by Divine Authority, by Industry and Experience, by an Inborn Idea, and Instinct in Nature; it was ordained for me by God Almighty, from my Mother's Womb. My Knowledge in the Mathematicks is but little, therefore I dare not compare my self to the Learned Dr. Wallis, and many others, who have writ large Vollumes of Geometry, Algebra, and Cubick Æquations. Brother Tar, there have been in England, many Pretenders to the Longitude, and some have writ concerning it; If thou hast this small Treatise by thee, thou mayst find more in it fit for thy purpose and Perusal, then

in

in any former Book of this Nature; there have been many Persons, when they have attained some Knowledge in Cosmography, *and Accidentally thinking on some of the ways contained in this Book, believe they have found the* Longitude, *and trouble their Brains to little purpose. Therefore, this* Book *is very convenient to ease their* Brains, *from such Burdens; because it contains all the most noted ways, and Fundamental Principles, whereby the most* Learned *of this Age, have endeavoured to find the* Longitude; *and whereas you may think that this Book doth not wholly inform you of any Practical Method, for finding the* Longitude; *yet it is hoped that the said Science will become Practicable, in few Years, (and already is to the Ingenious,*

but not to the Ignorant.) Till then I advise you, duly to consider the Fifth Chapter in this Book, concerning Magnetick Variation, which if you understand well, you have gained a Stience, that for Seamen's Practice, is little Inferiour to the Longitude: How the World may esteem of this Book, I cannot tell, but I hope it will be as a Safeguard, or means to save many a Ship from being Wreckt Ashoar, and save many a Seamans Life. Some Blockheads are apt to say, the Longitude cannot be found; no, no, it cannot Accidentally, as a Sow does a Turnip in the Streets, but by Care, Diligence, and Industry, it may be found, without which, it cannot be understood. Though we have been at the Dutch for Hydrographical

and

and Geographical Draughts, let us not go the to French to learn their Use. But why do I reflect, I expect no Thanks for my Pains, but to be reflected on again, as Harrison's Whimsies, or the like; I pray forsooth, how many such Whimsical Inventions can my Country-Men boast of, that they have not borrowed? I have often heard them boast of Drake and Candish, Sailing the World about, but not a word of the Portugueses that shewed the way. If any Envious Person pretend I have borrowed most of my Book, may he be obliged to Quote the Authors, where I have not; I advise some Mathematick Bookseller, for his and the Publick Good, to Re-print Mr. Street's Astr. Car. with its Appendix and Kalendar, and to Add a New and more Easie

Theory

Theory *of the* Moons *motion, by* Mr. Halley *or* Mr. Newton; *Tables of* Jupiters Satellites, *and a Catalogue of fixed* Stars, *and their true places, by* Mr. Flamſtead, *if they are to be had; if not, to borrow from* Mr. Caſſini, *and* Hevelius. *Some of the ordinary* Mathematicians *may hate to be out-done by a* Tarpolin, *if they have ought to ſay againſt him, its becauſe his Practice and Experience may prove him to be a more Competent* Artiſt *in Navigation then themſelves: If I have Committed ſome* Blunders, *the Name of* Tar, *and the Novelty of the Subject, may Excuſe me to the Judicious.*

Your Friend
and Servant,

Edward Harriſon.

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THE

Idea Longitudinis:

BEING

A brief Definition of the best known *Axioms*, for finding the LONGITUDE, &c.

CHAP. I.

Concerning a First Meridian.

DIvers were the Opinions of the *Ancients*, about the middle and *Center* of this World; before *Christianity*, the European *Heathens* esteemed those places as the *Center* of this World, where their Gods were chiefly Worshiped; as at *Delphos*, for *Apollo's Oracle*, at

Epheſus, for *Diana's Temple*, *&c.* The Primitive *Chriſtians*, believ'd *Jeruſalem* to be the middle of the World; *Ptolomy* who liv'd *Anno Chriſti* 138. begun his *Longitude* at the moſt Weſtern parts, (as he thought) at the Fortunate *Iſlands*, now called the *Canaries*. *Lactantius* was of Opinion, that the Earth was a Plain, and not a round Body, and would not believe there was any ſuch thing as *Antipodes*, which is now received and embraced for a certain approved Truth. Since the *Earth's* Globular Form hath been diſcovered, there have been many diſagreeing Opinions about a firſt *Meridian*; *Geographers* beginning at St. *Michaels* at *Gratioſo*, at *Pico*; Some begin at the *Lizard* of *England*, others at *London*, ſome at *Paris*: A *Spaniſh* Merchant willing to prefer an *Iſland* to this Honour, writes, (*viz.*) *Nullum inveni inter Auctores, quos legebam concordiam*; *aliis Heſperides Inſulæ pro primario meridiano placebant*; *quibuſdam Corui Inſula, pluribus fortunatæ Inſulæ, non nullis Palma Inſula, aliis alia atque alia loca*, &c. And a little further propoſeth an Iſland he

he calleth *Abroxos*, it lies towards the Coaſt of *Braſile*; ought he not, think you, to have been complained of to the *Pope*, for not knowing his Duty to St. *Peters Church* in *Rome*. The Reaſon why many begin their firſt *Meridian* from the Iſles *Azores*, is becauſe it is ſaid thereabouts, the Compaſs hath no *Variation*, (concerning which, I ſhall ſay more when I come to write of *Longitude* by *Magnetick Variation*.) Methinks they take up too much breadth for a firſt *Meridian*, for ſuppoſe I were to draw a large Draught of the *Azores*, or of the City of *London*, where muſt I place my firſt *Meridian*? a *Meridian-Line*, in a *Sea-Chart*, or *Map*, is no bigger then other Lines, ſave only ſo as to diſtinguiſh it from the reſt; beſides, *Aſtronomers* and *Aſtrologers*, pretend to obſerve and Calculate, to Seconds of Time, and Motion; therefore our firſt *Meridian* ought to be ſuppoſed to be a ſmall narrow Line, or Circle. I could Baſle and Impoſe on the World as our Predeceſſors have, falſe Arguments for other places, from whence they might account their firſt

Meridian. God forbid I ſhould be ſo wicked, Honour and Glory, and beginning of Good, belongs to God; a firſt *Meridian* may be repreſented, and if the Heads of our *Church* and *State*, think it good, let there be made a Figure, repreſenting a firſt *Meridian*, and Erected over St. *Pauls Church* in *London*, with this Inſcription, *Glory be to God, good Will towards Men*, this preſents our firſt *Meridian*, *&c.* this may be an Ornament to our *Church*; may it be *Sacriledge* for any of the *King* of *England's* Subjects, to account any other *Meridian* a firſt *Merid.* ſave that which paſſeth right over St. *Pauls-Church* in *London*, cutting the *Equinoctial* at right Angles, and paſſing through both its *Poles*. I hope this Advice may put a Period to Cavilling about a firſt *Meridian*; indeed I may except againſt wicked Captious, *Atheiſtical* Humours; for there was never any thing by the Wit of *Man* ſo well deviſed, or ſo ſure eſtabliſhed, which in continuance of time hath not been corrupted. It is always *Mid-day* or *Noon*, in ſome part of the World. Every *Meridian* is divided

vided into four Parts, or four times Ninety Degrees, and ſubdivided &c. They be Innumerable, but you may reduce them to what number you pleaſe, as to 21600, or half ſo many, or more, or leſs, as is moſt convenient for your purpoſe; they are all equidiſtant at the *Equinoctial*, and in every leſſer Circle, Paraliel to the *Equinoctial*, but Incline nearer together until they interſect one another in the *Poles*: I allow but one firſt *Meridian*, beginning at St. *Pauls-Church* in *London*, or if occaſion require, you may begin at any other part of the ſame *Meridian*.

CHAP. II.

A Definition of Longitude.

CIrcles of *Longitude* on the Earth, have their beginning at any part of our firſt *Meridian*, paſs round the Earth, and terminate where they be-

gun, may be imagin'd to be infinite in number, but may be reduced to what number you think moſt convenient for your purpoſe: There is but one great *Circle*, the *Equinoctial*; all Circles parallel to it, are leſſer and leſſer Circles, as they decline towards the *Poles*; each divided into 360°, and ſubdivided, *&c.* and may be accounted either *Eaſterly*, or *Weſterly*, as the Practitioner pleaſeth; it is our deſign to meaſure the Arches of theſe Circles, by *Aſtronomical* Obſervations, or otherwiſe, thereby to know our difference of *Longitude* from our firſt *Meridian*, when we are either to the Eaſtward or Weſtward of the ſame.

Longitude in the Heavens is accounted on one great Circle, the *Ecliptick*, (you may if you pleaſe, alſo Account it on leſſer Circles, parallel to the *Ecliptick*, but that is needleſs and not uſual,) which hath its beginning at the firſt point of *Aries*, or where the *Sun* will be this Year 1696, *March* the 9th Day, $3^{h.}$ 21′ 20″ *P. M.* it cuts the *Equinoctial* in two oppoſite points, in the beginning of ♈ and ♎; its greateſt

Obli-

Obliquity from the *Equinoctial*, (in theſe our Days,) is 23° 29′, it ends where it begins. The Theory of the *Planets*, and Stellary Motions, are accounted on the Arches of this great Circle, becauſe in their Revolution they reſpect the *Ecliptick Poles*, as their Center, (and the *Sun* alſo) and not the *Equinoctial Poles*, (except the *Earth* only, in her Diurnal Motion.)

Sydereal Longitude is accouted from the firſt Star of *Aries*, on the *Ecliptick* alſo; it begins where the *Ecliptick* is cut by a great Circle, that paſſeth through the 1 * of ♈ and the *Ecliptick Poles*; the difr. Long. between the 1 point of ♈, and the 1 * of ♈ is this Year the 9th Day of *March*, 28° 52′ 9″ which difr. is the præceſſion of the *Æquinox*.

CHAP. III.

A Definition of Time *and* Equation *of Natural* Days.

Atque in ſe ſua per Veſtigia, Volvitur annus. Virg.

OLD *Style*, or *Julian* Year, is our Engliſh Account, contains 365^{d} 6^{h}. of *Aſtronomical* years, there are divers kinds, but I ſhall only mention two, the *Solar*, or mean *Tropical* Year, is 365^{d} 5^{h} $49'$ $1''$ the *Sidereal* Year is 365^{d} 6^{h} $8'$ $30''$ the natural Day in moſt parts of *Europe*, is divided into 24^{h} the *Suns* (or *Earth*) mean motion in the *Ecliptick* in 24^{h} is $59'$ $8''$ the longeſt natural Day is 361^{o} $1'$ $15''$ the ſhort eſt is 360^{o} $57'$ $10''$ the difr. in one Day is but little, but in a Months time is conſi derable; each difference adjuſted is called *Æquation* of natural Days; the ſhorteſt natural Day, will be this Year the 18th Day of *June*, when

when the *Sun* is in 7° of *Cancer*, or thereabouts, for then the ☉ and ☽ are in their *Apogæon* (or *Auge*, *Apoge*, *Aphelion*, *Absis*, have all one Signification in *Astronomy*,) the 17th Day of *December*, they will be in their *Perigæon*, or *Perihelion*, or nearest distance; this Inequality of Natural Days, seems to me, to be the cause why our *Summer* half *Year* is (now in our times,) almost Eight *Days* longer, than our *Winter* half *Year*; as also it is the cause of the Impossibility of any *Clock*, or *Watch*. (though they move very regularly,) always to shew the true time of the Day; Mr. *Parker* in his *Almanack*, teacheth us when to Add or Substract the *Time* æquated to or from the mean time, to accord with the Apparent *Time*: In most *Books* of *Astronomy*, there are Tables for our purpose, *Vide Astr. Ang.* lib. 3. p. 84 and 85. *Canones Æquationum Dierum Naturalium*; & *Canones Equationis dierum Naturalium, duabus præcedentibus Compositi, & nostro huic Seculo citra errorem sensibilem subservien.* And *Ph. transf.* N. 214. pa. 248. *Tabulas æquationis Dierum, cum*

Solis

Solis loco adeund. &c. All which Tables you muſt well underſtand, before you can attain to Practical *Longitude*, (except *Magnetick Variation*,) it may ſeem neceſſary here, that I ſhow how to find the time of the Day or Night by Obſervation; there are many ways Publiſhed in ſeveral Mathematick *Books*, but I ſhall reduce them to one, (for I think Mr. *Molineux*'s *Sciotericum Teleſcopium*, will do us little or no ſervice) right way, and commend you to *Colſon*'s *Callender*, ſee his *Aſtronomical* Problems, *Prob.* 9 and 10. inſtead of Hours and Minutes, work by Degrees and Minutes; and whereas I ſaid that 360° 59′ 8″ was equal to 24 Hours; you may work only by 360° for when you obſerve in the Night, it is ſuppoſed you take the *Sun's* right *Aſcenſion* exactly true, at that very *Time* and *Place* of your Obſervation, allowing for the Suns Diurnal difference of R. A. alſo allowing for your difference of *Longitude*, from our firſt *Meridian*, elſe all your trouble may prove good for nothing. As yet I have never ſeen any *Univerſal Ring-Dial*,

or

or other *Sun-Dial*, that ſhewed the true Time of the Day, (except about Noon) our *Dialiſts* thinking the Suns *Refraction* not worth their notice, but thoſe that pretend to find the *Longitude*, muſt duly conſider *Refractions* and *Parallaxes*.

It ſeemeth not proper in this Chapter, but I think it convenient to add ſomething concerning *Inſtruments*; common Practice, and Experience teacheth, that a Foreſtaff is a uſeful *Inſtrument*, both for backward and forward Obſervations; I have alſo had Experience of it my ſelf. and for forward Obſervations, I like it not (and for backward *Davis*'s *Quadrant* is better;) for in its uſe, there happen ſeveral Errors, hard to Correct; as the Excentricitie of the *Eye*, and end of the *Staff*; a true *Horrizon* cannot be found by it in the Night, but only gueſſed at; beſides the height of the *Eye* above the Water, and the great difficulty of ſeeing two Objects at once, that is the *Sun* or *Star*, and the *Horizon*; for if the *Star* be high, whilſt you are a looking for it at one end of the *Vane*,

you

you looſe the *Horrizon*, at the other end of the *Vane*, or a looking for one, you loſe the ſight of the other; therefore to avoid ſuch Errors, for taking Altitudes in the *Night*, I commend you to a *Quadrant*, with a *Pendulum* from its *Center*; ſee the Figure of it in *Moxon*'s *Tutor* to *Aſtr.* Prob. 13. p. 48. This *Inſtrument* may ſeem very troubleſome at firſt, for want of Uſe and Cuſtom; uſe a weight of at leaſt two or three *Pound*, with a ſmall *Wire*, or *Catts-Gut*; for taking ſmall Heights, or Diſtances, you may uſe an *Almicanter Staff*, for ordinary Uſes; but if your Obſervation requires greater exactneſs, *Vide Tichonis Brahe, Aſtronomiæ Inſtauratæ Mechanica*, or *John Hevelii Machinæ Cæleſtis pars prior, &c.* inſtead of *Inſtruments*; that reſolve *Mathematical* Queſtions, as *Sectors* upon *Quadrants*, *Analemmas*, &c. Stick cloſe to the Doctrine of plain and *Spherical Triangles*, and to *Logarithmical Tables*; but on better Conſideration, the *Quadrant* in *Moxons* Tutor to Aſtr. aforeſaid, is not very fitting for Sea Uſes, without ſome Alterations, therefore I have contriv'd

a *Quadrant* ſomething like the former, with weights that Commands it, ſo that it will always continue in the ſame poſition you direct it to; It may be contriv'd to hang like a pair of Scales or *Ballance*, having an *Axis* in its Center, of Gravity, on which it is equally poiſed (without the weight) to turn round, having a *Swiſle* and *Ring* to hang or hook to any convenient place in the Ship, or thoſe that pleaſe may have a Stand purpoſely for it; there muſt be a ſmall Line, or ſlippery Cord or Cords faſtened ſomewhat ſlack, from Corner to Corner, on the Circumference of the *Quadrant*, on which Cords hang the weights of 20 or 30 Pound, or more or leſs, as you find moſt convenient for the Subſtance or Radius of the Quadrant; from the ſaid weights, or rather from that part that ſlides on the *Cords*, may come two *Indexes*, one to point to the Altitude on one ſide of the Quadrant, and the other, to the Comp. Altitude, if the *Quadrant* be revers'd on the other ſide; and thoſe that pleaſe may alſo have either *Pendulums* or *Indexes*, from the Center of the *Quadrant*

drant, to point either to the Degrees of Altitude, or Comp. Altitude: It is eafily managed in blowing Weather at Sea, or Aſhoar, and the Price not above 20 Shilling, I hope, for a Common one; I am a little Proud of the Invention, however I forbear to Applaud it too much, and to Print the Figure of it, till I have made further Experience of it.

CHAP. IV.

Of Automata's, *or* Horological *Self-Movers.*

MR. *Blundeville.* from *Gemma Friſius*, writes of a ready way (as he calls it, (to find out the *Longitude* of any place, by ſome true *Horology*, or *Watch*; to that purpoſe, Mr. *Rook* writes, *viz: Ad momenta temporis accuratiſſime notanda (quod in hujuſmodi Obſervationibus eſt palmarium) perutile erit Oſcillatorium, ab Ingenioſiſſimo & candidiſſimo Hugenio feliciter excogitatum:*

There

There have been ſome Experiments made at Sea for finding the *Longitude* by *Pendulum Watches*, as you may read in the Ph. tranſ. N. 1. pa. 13. I know ſeveral *Seamen* will buy this *Book*, that are not able to furniſh themſelves with a Sett of Ph. *Tranſactions*, therefore it may be convenient to Inſert the following Narrative.

A Narrative concerning the Succeſs of Pendulum Watches *at* Sea, *for the* Longitudes.

The Relation lately made by Major *Holmes*, concerning the Succeſs of *Pendulum Watches* at Sea, (two whereof were Committed to his Care and Obſervation in his laſt Voyage to *Guiney*, by ſome of our Eminent *Virtuoſi*, and grand Promoters of Navigation,) is as followeth. The ſaid *Major* having left that Coaſt, and being come to the Iſle of St. *Thomas*, under the *Line*, accompanied with four Veſſels, having there adjuſted his Watche, put to Sea, ſailed Weſtward, ſeven or eight Hundred

dred Leagues, without changing his Courſe; after which, finding the Wind favourable, he Steered towards the Coaſt of *Africk*, North North East, but having Sailed upon that *Line*, a matter of two or three Hundred Leagues, the Maſters of the other Ships, under his Conduct, apprehending that they ſhould want Water, before they could reach that Coaſt, did propoſe to him, to ſteer their Courſe to *Barbadoes*, to ſupply themſelves with Water there. Whereupon the ſaid Major, having called the Maſter and Pilots together, and cauſed them to produce their Journals and Calculations, it was found that thoſe Pilots did differ in their Reckonings, from that of the Major; one of them Eighty Leagues, another about an Hundred, and the third more; but the Major Judging by his *Pendulum Watches*, that they were only ſome thirty Leagues diſtant from the Iſle of *Fuego*, which is one of the Iſles of *Cape Verd*, and that they might reach it next Day, and having a great Confidence in the ſaid Watches, reſolv'd to Steer their Courſe thither, and having given Or-

der

der ſo to do, they got the very next Day about Noon a ſight of the Iſle of *Fuego*, finding themſelves to Sail directly upo it, and ſo arrived at it that Afternoon, as he had ſaid. Theſe Watches having been firſt invented by the Excellent Monſieur *Chriſtian Hugens* of *Zuilchem*, and fitted to go to Sea, by the Right Honourable, the Earl of *Kincardin*, both Fellows of the *Royal Society*, are now brought by a New Addition, to a wonderful Perfection; the ſaid Monſieur *Hugens*, having been informed of the ſucceſs of the Experiment, made by Major *Holmes*, wrote to a Friend at *Paris*, a Letter to this effect.

Major *Holmes* at his return, hath made a Relation concerning the uſefulneſs of *Pendulums*, which ſurpaſſeth my Expectation; I did not imagine that the Watches of this firſt Structure, would ſucceed ſo well, and I had reſerv'd my main Hopes for the New ones: but ſeeing thoſe have already ſerv'd ſo ſucceſsfully, and that the other are yet more Juſt and Exact, I have the more Reaſon to believe, that

the Invention of *Longitudes*, will come to its Perfection. In the mean time, I ſhall tell you, that the *States* did receive my Propoſition, when I deſired of them a Patent for theſe New Watches, and the recompence ſet apart for the Invention, in caſe of Succeſs; and that without any difficulty, they have granted my Requeſt, commanding me to bring one of theſe Watches into their Aſſembly, to explicate unto them, the Invention, and Application thereof to the *Longitudes*, which I have done to their Contentment. I have this Week Publiſhed, that theſe Watches ſhall be expoſed to Sale, together, with an Information, neceſſary to uſe them at Sea; and thus I have broken the Ice. The ſame Objection that hath been made in your Parts, againſt the Exactneſs of theſe *Pendulums*, hath alſo been made here, to Wit, that though they ſhould agree together, they might fail both of them, by Reaſon that the Air at one time might be thicker, then at another. But I have anſwered, that this difference, if there be any, will not at all be perceiv'd in the *Penduls*, ſeeing that

that the continual Observations made in Winter, from Day to Day, until Summer, have shewed me, that they have always agreed with the Sun, (*I doubt the Truth.*) As to the Printing the *Figure* of my New Watch, I shall defer that yet a while; but it shall in time appear, with all the Demonstrations thereof, together with a *Treatise* of *Pendulums*, written by me some Days since, which is of a very subtle Speculation.

I have read of a Glass *Globe*, that a *King* of *Persia* had, in which he could see all the Celestial Motions; of the same kind with our Clocks and Watches, though perhaps more Elaborate and Subtle, was that *Sphere* Invented by *Archimides*, which did represent the Heavenly Motions, the Diurnal and Anual Course of the Sun, the Changes and Aspects of the Moon, *&c.* This is frequently Celebrated in the writings of the Antients.

Jupiter in parvo cum cerneret æthera Vitro,
Risit, & ad Superos talia dicta dedit;

Huccine mortalis progressa potentia curæ?
Jam meus in fragili luditur orbe labor.
Jura poli, rerumque fidem, legesque Deorum,
Ecce Syracusius transtulit arte Senex.
Inclusus Variis famulatur Spiritus astris,
Et Vivum certis motibus urget opus.
Percurrit proprium mentitus Signifer annum;
Et simulata novo Cynthia mense redit.
Jamq; suum Volvens audax instria mundum,
Gaudet & humanâ sidera mente regit.
Quid falso insontem tonitru Salmonea *mirer?*
Æmula natura parva reperta manus.

I have heard from *Dutch* Seamen several Stories of a wonderful *Sphere* or Clock at *Strasburgh* in *Germany*, which as they say, hath or had a regular and perpetual Motion, and shewed the Cœlestial Motions, *&c.* Mr. *Newton* in his *Idea of Geography* and *Navigation*, pag. 90 and 91. writeth concerning *Automata's*, or unerring Clocks, and saith, that the nearer you advance within the Artick or Antartick Circles towards either of the *Poles*, the Mo-

Motion is so much slower then at *London*; but in his Preface to the Reader, saith, This Paragraph, ought thus to be Corrected, that the further you advance towards either *Pole*, their Motion is swifter, and the further they are carryed towards the *Equator*, their Motion is retarded, &c. The cause wherefore these Instruments may move swifter nigh the *Poles*, then near the *Equinoctial*, cannot proceed from the Oval Form of the Earth, as some think; the cause of their swifter Motion nigher the *Poles*, in my Opinion is cold Weather, and Frosts; I believe that in *England*, in Frosty Weather, our Clocks move swifter then in Summer, for in Frosty Weather, Springs may contract a little, and grow stiffer, consequently have more force to make a swifter Motion; and in Hot Weather they may extend, and be a little more pliable, therefore the Motion may not prove altogether so swift as in *Frosts*: There are other Causes also, that may hinder the regularity of their Motions; see Ph. tr. N. 47. p. 951. and 976. Some may desire to know my Reasons for Springs, contracting in *Frosty* Weather,

take a piece of Cold *Iron* or *Steel*, one or two Foot long, about $\frac{1}{2}$ or $\frac{1}{4}$ of an Inch Square, heat it red hot, keep heating and well Hammering it hot an Hour or two, when you have done, measure its length exactly before it be Cold, lay it aside in the Air, where the *Frost* may ting it a Winters Night, and if you measure it in the Morning, you will find it considerably shorter. Experience teacheth, that there are few *Watches* that have a regular Motion; for it seems impossible, that the *Springs* in all their parts, should be so exactly Hammered, as to draw always equally, and by what I can learn from *Watch-makers*, a ballsnce Watch that requireth winding up every 24 Hours, keepeth time more exact, than one that goeth a Week, before it need winding up. About Seven Years ago, my curiosity carried me to *Gresham Colledge*, when the Assembly was seated, the *President* told me, they had caused several Experiments to be made with these *Instruments*, and thought fitting not to commend them for Common Practice at Sea, for fear that the Errors

that

that might happen in their uſe, ſhould prove greater then the Errors in the common Practice of Navigation; but now let us handle our Subject a little more cloſely, and ſuppoſe that three or four of the ſaid *Watches* being good work, well made, and carryed to Sea in one *Ship* under the Command of Ingenious Men, may prove very uſeful towards the keeping a true Account of a *Ships* way on the Sea, not for finding the *Longitude* from our firſt *Meridian*, but to help to find your difference of *Longitude* every 24 Hours, or every two or three Days, as often as you obſerve the Lattitude; provided they be not too much tampered with, keeping the Indexes always moving, but never move them with your Fingers, except extraordinary occaſion require it; deſire not that they ſhould always ſhew you the true time of the Day, (you may if you pleaſe, keep one for that purpoſe beſides,) but learn by continuance of time, to find the Motion of each *Watch* in a Year, or in a Month, or Day, and Hour, and having the true Theory of each *Watches* Motion, with their

equalities and inequalities, you may by Calculation find at what time of the Day or Night the Indexes of each *Watch*, (for I ſuppoſe, they may not all move juſt alike,) will point to ſuch or ſuch an Hour, Degree, or Minute, in any *Meridian*; keep them from being hurt by any *Violent Motion*, as falls, or knocking near them; keep them from Winds, from too moiſt *Airs*, and ſtinking *Fumes*; ſuch as are when Salt Water Casks are emptied on *Deck*, or in a Ships Well, where Men have been Stifled; keep them very clean from *Salt Water*, or any *Ruſt* or *Filth*; let there be a place in the *Ship*, properly appointed for them, to hang in *Equilibrio*. I find in the Ph. tranſ. N. 47. p. 937. Inſtructions concerning the uſe of *Pendulum Watches*, for finding the *Longitude* at Sea, together with a Method of a Journal for ſuch Watches, *&c. Brother Tar*, if theſe *Automada's* could ſpeak, (as the Welſh Man thought,) they would tell thee, they hate Novices; and if thou art ſo, they may not bite thee, but they may happen to break thy Head, or do the ſome other

other Miſchief; or in a more plain meaning, I dare not approve of their uſe for the difference of *Longitudes*, except only in an East or West Courſe, or in Caſe of ſome unknown Currents, uſe thy diſcretion. The *Watches* that are now eſteemed moſt uſeful, have a *Pendulum* Spring to regulate the Motion of the ballance; thoſe that deſire to know more of theſe *Automata*'s and *Mechanical Motions*, may read *Biſhop Wilkin*'s his *Mathematical Magick*. Water-Glaſſes, 24 Hour Sand-Glaſſes, and ſuch like *Self-movers*, are of no uſe in this Science, though I have mentioned them for Vulgar Satisfaction only; but of what uſe *Mercurii* or *Quick-ſilver* may prove in keeping time true by the regularity of its Motion in Glaſſes, I cannot yet inform you.

CHAP.

CHAP. V.

Of or concerning Longitude, *by* *Magnetick* Variation.

THE *Variation* of the Compass (by which I mean the deflection of the Needle, from the true *Meridian*,) is of that great concernment in the Art of Navigation, that the neglect thereof does little less then render useless, one of the noblest Inventions Mankind ever attain'd to; I desire the Ingenious Seamen, that the knowledge of *Magnetick Variation*, may be always in his great Esteem; for without it, Navigation cannot be perfect. It is my Opinion, that many Ships have been put by their design'd Ports, and more Ships lost for want of knowing the *Variation*, then hath been lost for want of the *Longitude*; how many Ships in Sailing from the *South-fore-land*, to the *Maese*, hath been put to the Northward of the *Maese*, for want of minding the *Variation*? for the like cause, some Ships have

have missed the Island *Barbadoes*, and met with other dismal Accidents. Mr. *Edward Wright*, an able Mathematician in his time, in the latter end of his Correction of Errors in *Navigation*, did write concerning the *Haven finding Art*, by the *Variation* of the Marriners Compass, but alas he knew nothing of the *Variation* of the *Variation*, or as I call it, of the Increase and Decrease of the *Variation* in the same place; therefore that part of his Book proved very Erroneous, by supposing that the *Variation* at any place, never Altered, now we know better.

There are many of Opinion at this present time, that the *Longitude* may be found by the *Variation* of the Magnetical Horizontal Needle; I doubt the possibility thereof, from our first *Meridian*, for many parts of the World will afford us no Practicable proportions for the difference of *Variation* between them, according to their distance in *Longitude*; nor can the quantity of the Earths Attraction, be easily determin'd in all places, besides the quantity of each *Polar* Attraction, for there are four,

at

at leaſt two, of them lie in the bowels of the Earth, and not in the Air, as Mr. *Pond* ſaith; it is probable that theſe *Magnetick Poles* have a Motion from North to South, but whether they move altogether with one Motion, or with ſeveral; whether equally, or unequally; whether Circular or Libratory; if Circular, about what Center? If Libratory, after what manner, are Secrets as yet unknown to Mankind; That which I call the more proper North *Magnetick Pole*, Predominates at *London*; and the Period of its motion, as ſome ſay, is about 370 Years; and others write, that the Period of the Motion of the *American Pole*, is about 700 Years; ſome think the *Magnetical* Inclinatory Needle, always points directly to one of theſe *Poles*, which I dare affirm to be an untruth, and can prove it by Practice, Experience, and Infallible Demonſtrations. The mean Motion of the *Variation* here at *London*, is about eight Minutes, or ſomewhat more in one Year; it is my Opinion, that moſt places in the World, have not altogether ſo ſwift an Alteration of the

Variation,

Variation, as at *London*; but in many other places it is a little ſlower, eſpecially near the Equinoctial; for the nearer one of theſe Poles is to any place, there encreaſe or decreaſe of the *Variation* may be ſwifteſt. As the *Sun* in the *Tropicks*, differs his declination but ſlowly, ſo the Horrizontal *Needle*, is in its ſloweſt Motion, when it hath the greateſt *Variation* Eaſt or Weſt, at *London*; and whereas ſome places have above 22 or 30 Degrees *Variation* North-Weſterly, I doubt thoſe places will not have above 22 Deg. *Variation*, North-Eaſterly, in one Revolution of the ſaid Poles. That all Magnetical *Needles* well toucht, have the ſame direction exactly, as Mr. *Sellers* hath proved by many Experiments, ſee Ph. tr. N. 26. p. 478. but if badly toucht, they may vary ſometimes one or two Degrees from the true *Magnetical Meridian*, as often happens at Sea, as our Marriners ſay, that the Compaſs in the upper or lower beetackle, ſometimes varies near half a point from each other; I have often taken notice of their expreſſions, and tryed to find the cauſe;

and

and when I found no Iron near them, (or the like Obſtructions,) that might draw me off the Compaſſes, I have found that one, and ſometimes both, had a a weak touch, or Old and Ruſty, and good for nothing, except to throw overboard, *&c.* Five Hundred ſuch Compaſſes, I believe, at this preſent writing, may be found belonging to the *Navy*, *&c.* A true Knowledge of the *Variation* is very requiſite in keeping a Sea reckoning; it troubles me to think what Ignorant Perſons are *Maſters* of Ships; it is ſcarce two Years ſince, in my company, ſome *Maſters* of Ships, complained of a wrong Courſe ſteered by their *Comodores*, who in the Night by a fair Wind, were carryed too near the Borlings, even ſo near, that ſome of them were oblig'd, (as I was inform'd) to go between the *Borlings* and the *Main*. This Error happened for want of good underſtanding *Maſters* in the *Comodores* Ships, they knew not the *Variation*, elſe forgot to allow for it; for though the true Courſe from the *Lizard* to *Cape Finiſter* be S. S. W. the Courſe to be Steered by Marriners Compaſs,

Compaſs, at preſent, is S. S. W. ½ W. and S. W. by S. It is ſcarce one Year ago, (to this preſent writing,) ſince a *Maſter* of a —— Rate Ship told his Captain, that he obſerv'd 14 or 15 Deg. *Variation* about 6 Leagues off of *Malhago* by the Stars, (there is about 6 Deg.) If I may compare a Man to a block, that ſame Man knew little more how to find the *Variation* by the North Star, or any other Star, than a Buggilug or Bracket on that Ships Quarter; I doubt whether or no, he ever ſaw an *Azimuth Compaſs*. When you would obſerve the North Star, to find the *Variation* in the Night, conſider its diſtance Eaſt or Weſt from the *Pole*; a *Nocturnal* may be of good uſe in this Caſe. *England* does not know how many loſſes hath happened for want of a better Knowledge in the *Variation* of the Compaſs through only a Pilot of a Ship: ſuppoſe between the Bunt-Head and the K. K. or *Gunfleet*, if he underſtands not the *Variation*, he may in my Opinion, as well deſerve a Rope, as a Branch. But the *Extra.*-Pilots will blame me for mentioning *Variation* or

Courſe

Courſe in Pilot Water, where the Strength and Courſe of Tides and depths of Water, is of much more Conſequence. My *Lord's Commiſſioners* of the *Admiralty*, &c. You have been pleaſed to give us a Form to keep our *Journals* at Sea; there is in my Opinion two Columns wanting in that Form, that Column for *Longitude*. If you pleaſe, my *Lords*, let it be accounted from our firſt *Meridian*; may there be added one Column called *Meridian* Diſtance by *plain Chart*, and accounted from the laſt Land ſeen; and another for the *Variation* of the Compaſs. I have belong'd this War to Six ſeveral Rates in the Navy, and never ſaw an *Azimuth Compaſs* Aboard any of them; my Judgment tells me, that every Ship of War, requires at leaſt three ſuch like *Inſtruments*, to obſerve the *Variation*, though they ride only at an Anchor, at the *Nore*, or in the *Downs*; the Commiſſioners of the Navy have taken Care to provide ſuch *Inſtruments*, and I believe the *Maſters* of Men of War, may have them for asking for, (for the *Boatſwains* Indent for them.) I believe they

they are ashamed, (or ought to be,) for some of them knows not what to do with them; the Instruments if well used, may be a means to help to save a Ship, and Ships Companies lives; they are good to be used for the Instruction of Ships Company and Youth, there is Education in the *Navy*, (little enough,) that is good: Navigation seems to decay, or decline; I wish it be not a Crime, for some Gentlemen in the *Navy*, to understand it. Now I will say something to my Honourable *Company Masters*; little do they know, how many Ships have been lost for want of a better Knowledge of the *Variation*; I believe I could name some, (and several in great danger by report,) but dare not fear of the *Law*: Captain *William Wilday* understood the *Variation* very well in my Opinion, I believe it was almost as good to him as the *Longitude* between St. *Hellena*, and any part of the *East-Indies*. When I was in *East-India*, I understood what *Variation* there was in most Adjacent Parts so well, that I have offered in Discourse in Company, to go in a Ship that set Sail from

any part of the Coast of *India*, bound any way, two three or four Hundred Leagues, I would keep no Account of her way for a Week or ten Days time, and any fair Day when I could have Reasonable Observations, I would a told them the place where the Ship was, as well as they that kept the most exact Reckoning, (almost as well, if you please) provided they had not seen the Land since I saw it; and this I must have done by the *Lattitude* and *Variation* obsery'd, *October* the 30th, 1688. in the Offing at *Cape Bona Esperance*, the Cape bearing from us about North, distant 6 or 7 Leagues; the mean *Variation* by three *Azimuth Compasses*, and Nine Observations, was 10° N. Westerly; the same Year, *November* the 16th, *Variation* at St. *Helena*, 1° 4′ N. Westerly, the difference is 8° 56′ the the *Meridian* distance, by *plain Chart*, is 20°, difference of *Longitude* is 21° 54′, in Sailing directly between the two aforesaid places we raised or layed (Sea Terms,) the *Variation* somewhat gradually, therefore having the difference of *Longitude*, and the difference

of

of the *Variation* given between the two ſaid places, it may be ſuppoſed that the difference of *Longitude* between the places, may be found by Obſervation of the *Variation*; I anſwer yes, it may be nearly gueſſed at, and I know how to make proportions for finding the difference of *Longitude* by the *Variation*, not only between the two aforeſaid places, but in many other places. But it is a Method I do not approve of, and adviſe the Induſtrious Seamen not to uſe it, (except in Caſes of great Neceſſity,) but rather to learn by former Journals, or from ſome Experienc'd Artiſt, what *Variation* is at ſuch places where you are bound to, and all along your Voyage as near as you can, notwithſtanding the *Variation* of the *Variation*: I believe the difference of the *Variation* between any two places in *Eaſt-India*, may be always near the ſame; and not only there, but in moſt other parts of the World (near the Iſles *Azores* excepted,) that are not above 20 or 30 Degrees diſtant aſunder; this I recommend as a Secret, worthy Obſervation. But there are ſeveral places that will

not allow of any proportions like the former; as the *Downs*, the Chanel of *England*, and ſeveral Degrees Weſterly, from *Uſhant*; there is but little difference in the *Variation*: The *Variation* alſo alters apace in Sailing N. or S. under the ſame *Meridian*, not always gradually, but in ſome places faſter then in others. It is found by Experience and Practice, that the Morning *Variations* are the greateſt, as I have found ſometimes near 30 Minutes; and my Opinion is, that this difference happeneth not from the Oval Form, or Eliptical Motion of the Earth, but that the Suns *Refraction* is conſiderably greateſt in a Morning; if the Suns greateſt *Refraction* be but 34′ as our Aſtronomers affirm; how came it to paſs, that ſome *Engliſh-men* and *Hollanders*, that Wintered in *Green-land*, and *Nova Zembla*, ſaw the Sun five Days ſooner then was expected, according to the Latitude of the place; but to prevent the former difference or Error, ſubſtract the Suns *Refraction* from the obſerved Altitude, allowing the *Refraction*, when the Sun is in the Horizon,

Horizon, to be a few Minutes more in a Morning then in the Evening; I cannot at present Certifie you how many Minutes the difference is, becauſe I have loſt my former Amplitudal Obſervations. It is a Fault in our *East-India* Commanders, that they have not uſed to Subſtract the Suns *Refraction*, &c. (they commonly take the Suns Declination from the preceeding Noon, which is alſo a great Fault.) *Vide Aſtr. Ang.* page 94. *Tabula Refractionum Triplex*. But near the Poles it is probable, the Suns *Refraction* is greater, then near the Equinoctial: If the *Variation* of the Compaſs were better known, and Tables of the *Variation*, for all the moſt noted parts in the World, as Headlands, Capes, Iſlands, &c. The Tables Calculated to a certain Year, becauſe of the Increaſe and Decreaſe of the *Variation*, and the difference of the *Variation*, between thoſe places; then the Knowledge thereof would be almoſt as good as the *Longitude* known, (ſome few places excepted,) and if there be 10 or 20 Years difference, in laying or ſetting down the *Variation* in

ſome places, it matters not, provided the Year be ſet down, when the *Variation* was ſo much at ſuch places, and whether *Increaſing* or *Decreaſing*, as for Example; ſuppoſe in the Year 1708, one ſhould happen to be 10 or 12 Leagues South, off of C. B. *Eſperance*, and find the *Variation* 12° 28′ as I told you before, the difference of the *Variation* between the ſaid *Cape* and St. *Hellena*, is 8°. 56′ by which Rule, when you are at the ſaid *Cape*, you may know what the *Variation* is at St. *Hellena*, *viz.* 3° 32′ both N. Weſterly, increaſing; the like Examples may be conſider'd of moſt other places in the World, that are not above 20 or 30° diſtant aſunder, (except about the *Azores*.) I preſent you with another Method, *viz.* When we have ſuch or ſuch *Variation* at *London*, thereby to know what *Variation* there is in any other part of the World; for if at this preſent writing, I know exactly what *Variation* there was in all parts of the World, I believe it would be no hard matter then by knowing the *Variation* at *London*, to find what *Variation* there

there was in other parts, in future Ages. This Method I recommend to the Conſideration of the Ingenious, as alſo to ſee, if they can find the *Latitude* and *Longitude* of each *Magnetick Pole*; but ſome People will think, I have writ nothing to the purpoſe, if I do not tell them wherefore there is little or no *Variation* about the *Azores*: the quantity of the Earths Attraction, is but little in ſome places, two Degrees or three, may be the moſt, and in moſt places at Sea, the more ſolid parts of the Earth, have no Attractive quality, for then the Needle is without the Command of the more *Magnetick* Vigor of the Earth, as for Example, in the Year 1688, about 8 or 10 Leagues at Sea, in the Offing at C. B. *Eſperance*, when we had about Ten Deg. *Variation*, I was told by Experienced Artiſts, that there was not above 7½ or 8 Deg. at moſt *Variation* Aſhoar, or in the Harbour at the *Cape*, which is a very quick Alteration, for any where thereabouts, above Ten Leagues off at Sea, in Sailing on any point of the Compaſs, 10 Leagues, you will not alter your *Variation* above 12

of 14 Minutes at moſt: The like Experiment hath been proved on the Coaſt of *India*, and in the *Meriterranean*. Therefore it is evident, that Promontories, Capes, and Head-lands, draw the Compaſs a little, and that only when you are near them, within 10 or 12 Leagues; beſides the Earths quality of hindering it from pointing to its *Poles*; there are four *Poles* (at leaſt) which have a Sympathetical Virtue, with the *Magnetical Needle*, to which it naturally inclines; two of them that are furtheſt within the Earths Orb, I call its more *proper Poles*, and the other two in the *Cortex* of the Earth, the *Magnetical Poles*; theſe four *Poles* draw the *Needle*, ſome one way, and ſome another, ſo that they hold it amongſt them, each requires a ſhare; but that *Pole* Predominates moſt, to which it is neareſt: The Iſles of *Azores* I account lies almoſt between the two *proper Poles*, which two *Poles* always (for ought I know,) bear N. and S. from thoſe Iſlands, for there it is without the Attraction of the *Magnetick Poles*; but I believe there is ſome *Variation* at the

Azores,

Azores, and will be more in time. If the *Magnetick Needle* were very high up in the Air, it would have no reſpect to the Earth, or to any *Poles* but its own, or *Center*; this is my Opinion. The cauſe of the quick Alteration, and great *Variation*, at *New-found-land*, and ſome other places; I would alſo tell you my Opinion, but I am afraid of ſeeming tedious, with Tautologies.

In uſing *Azimut Compaſſes*, take care the *Chart* Librate well in the Box, and that the point of the Braſs Needle, on which the *Chart* Librates, be as exact as may be, in its proper place or *Center* of the Box; truſt not to one Obſervation, when you can have the Medium of 5 or 6 or more, nor to one Amplitude, when you may have the mean of 3 or 4 *Azimuths*; mind to ſubſtract the Suns *Refraction*, *&c.* Suffer no great Guns, or other Iron, too near your Compaſſes; thoſe are beſt that have the quickeſt *Motion*, you may try the points of the Needle, by ſeeing what Iron they will take up, but be very careful, and uſe it not often, for you may ſpoil the *Needle*. With a Needle

and

and round *Loadstone*, may be perform'd many Natural and pleasant Conclusions; but to think, that such a *Terrula*, (as they call it,) hath or represents the like *Magnetick* Force or Power, in all Species as the Earth, is a weak and ridiculous Opinion; whereas it may be thought in these parts of *Europe*, there is no occasion for carrying *Azimuth Compasses* to Sea, because it may be supposed most *Masters*, knows what *Variation* there is in most Adjacent places; it is a mistake, for the Major part, nay, of them, I believe, knows little or nothing concerning it, as I could prove by manifest Examples; If I were to declare what I know, and sometimes been an Eye witness to; but Truth ought not to be spoke at all times; besides, I am not willing to disobliege some Persons, that might think I reflect too much on them; those *Masters* that have understood something of the *Variation*, often forget it, for want of *Azimuth Compasses*, or for not being obliged to give an Account thereof: I have known some *Masters* of Ships, that knew, (by hear

may

ſay from others,) that in ſuch places, there was about half a Point Weſt *Variation*: I have asked them how they accounted it from what point of the Compaſs, (pretending my ſelf Ignorant,) they have anſwered, I might Account it from N. or S. E. or W. or from any point, it was always Weſterly; neither do they know how to eſtimate the *Variation* in their Reckonings; but it may be objected, how can the *Maſters* be ſo Ignorant, that go and come well from Port to Port; I anſwer *Thick'e, Weſt-Country-Man, lack zure, Life and Soul Man, can carry a Ship to* New-found-land *zure, and near a word a Book zure*; this is by long Experience and Cuſtom, not by Art; I have ſeen the Blind lead the Blind a Begging: I knew two Blind Men in *Cochin*, that would go very readily to any Houſe in that Town, and I have ſent one of them an Errand two Miles into the Country, but they were both born Blind; therefore by long Experience and Cuſtom, they naturally know moſt Adjacent places. As to *Maſters* or *Pilots*, their carrying Ships in and out of Harbours,

bours, and for the Coasting part, (when they can see the Land,) I have nothing to say against them; And if a mischance happens, you will rarely find any of them without a lying Excuse to salve their Ignorance. But it may be said, the *Masters* make Observations, and keep a Reckoning, yes, so they do, and a very bad one oftentimes. I will acquaint you how they do, that knows not how to allow for the *Variation*, as they ought; it is likely they can tell, whether they have Sailed between the *South* and the *East*, or S. and W. or N. and E. or N. or W. having wrought their Days Work by Log and difference. Latitude and Departure, they find what dist. the Ship hath run by Log. so having that dist. and diff. Lattitude by Observation, they can find, (as they think,) the *Departure*, without allowing for *Variation*; and this kind of Reckoning, is the cause of so many great Mistakes, in their Easting and Westing; for the Log. is but a false supposition, to find the distance run, as hath been Experienc'd in one Fleet, where some have had 70 Miles

on

on the board, ſome 80, and others about 90, the ſame 24 Hours, and all the while, not above a League aſunder. Now I will acquaint you with the beſt known Common Method, for keeping an Account of a Ships way on the Sea. Be as curious as poſſibly you can, in obſerving the Suns *Meridian Altitude*, or for want thereof, ſome known *Stars* to find the *Lattitude* by; if you obſerve with *Davis's Quadrant*, ſee your *Vanes* very carefully and exactly placed, eſpecially the Shade *Vane*; when the *Horizon* is very clear, obſerve ſomewhat cloſe, when hazy a little more open; theſe cautions I give, that you may obſerve every Day alike, and thereby the better to Judge of your true difference of Latitude by Obſervation, then work your Days work, and find what Courſe the Ship hath made, as near as poſſibly you can find it, by allowing for *Lee-way Variation, &c.* (or lying by, or any other Impediments, as Tides or Currents, or a great Sea,) and having the true diff. Latitude by Obſervation, and the Courſe given, you may eaſily find the diſtance run, and departure

ture by the common Method, and difference of Longitude by *Mercator*, &c. It is my Opinion, that the use of the *Log*, is good to help to find the Ships Course, though there are some able Artists that use no *Log*, but now to our purpose again, as for Mr. *Bond's Longitude found*, (as he called it) he limits his *Hypothesis* to the City of *London*, affirming himself (as he had a great deal of Reason,) that the same *Calculus* is not sufficient for other places, whereby it appears, that his Rule is far short, of the so much desired general one. The following digression may please some Capacities: *Famianus Strada*, in the Vein of *Lucretius*, writes, *viz.*

Magnesi genus est lapidis mirabile, cui si
Corpora ferri plura Stylosve admoveris, inde
Non modo vim motumque trahent, quo semper ad
Qua latet vicina Polo se vertere tement. (Ursam,
Verum etiam, &c.
Optinam hæc ratio scribendi prodeat usu;
Cautior & citior properaret Epistola, nullas
Latronum verita Insidias, fluviosque morantes,
Ipse suis princeps manibus sibi conficeret rem.
Nos soboles Scribarum emersi ex æquore nigro
Consecraremus Calamum Magnetis ad Oras.

But

But this Invention is altogether Imaginary, having no foundation on any real Experiment. The Royal *Society* in *London*, have a great Load-ſtone found in *Devonſhire*, that will move a Needle, at 9 Foot diſtance: Some Perſons may happen to Read this Chapter, that underſtand not Navigation, and think that moſt Ships are loſt for want of underſtanding the *Longitude*, or the *Variation*; I ſay, I believe ſuch Accidents may have happened, but very *rarely*; for moſt Ships have been loſt by many other Accidents, as *Storms*, or the like; Example, our great Loſs by Storms lately in the Streights of *Gibilaterra*, and the late *Hurricane* at *Barbadoes*, in which Ships I believe, were ſome as able Seamen, and Experienc'd Artiſts in *Navigation*, as the World did afford. The finding the *Lattitude* by the *Inclination* of the *Inclinatory Needle*, is at preſent thrown out of Doors, as of little or no account, as well it may, if we will be ſuch Novices, as to confine the *Inclinatory Needle* in a narrow *Cycloid*, as commonly it is, by which means it becomes uſeleſs at Sea, and not

mana-

manageable; therefore it ought to be contriv'd, to hang in *Equilibro*, so that it may have a free Circular Motion, any way on its Center of *Gravity*, and then it will much easier shew the *Inclination*, and *Variation* also, if need require it; and if the Theory of its Inclination were known, (all the World over) we might also find the Latitude by it.

The following words were forgot at the end of the 4th Chapter, *viz.* Our Countryman Mr. *Watson*, who made an Ingenious Clock (*for our late Queen*) which sheweth the Cœlestial Motions; and Monsieur *Didiers Cœlestial Globe*, shewing the apparent Motions from East to West, and from West to East, of the *Sun*, *Moon*, and fixed *Stars*, see *Ph. Tr*, *N.* 136. *p.* 895. I think a *Globe* may be *projected*, and made like the later, that may shew *Latitude*, *Longitude*, *Sun* or *Stars*, Horary distance from the *Meridian*, and *Variation*, *&c.* But it would be too *costly* for ordinary Uses, and nothing hinder its Truth or equal Motion, more then the different Temperatures of *Air* and *Weather*, though

though we may attribute something to the goodness of the Spring and Dyet

CHAP. VI.

Longitude by the Moon's *Motion, by her* Conjunctions *or* Eclipses, *and Apulses to fixed* Stars; *of her* Illumination *by the* Sun.

THE Question is yet unresolv'd, which time ought to be called the true Conjunction or Opposition, whether when the Sun and Moon are in one Line perpendicular to the *Ecliptick*, or perpendicular to the Orb of the *Moon*, or when they are equally distant from the *Nodes*. Mr. *Shakerley's Tabulæ Britannicæ, precept*, 15. *pag.* 67.

Let us Correct this Learned Mistake, and agree with most Astronomers, that it is always New *Moon*, when the *Sun* and *Moon* have both one *Longitude*, from the first point of *Aries*. The

mean motion of the *Moon*, in one Natural Day is 13° 10′ 35″ her mean motion from the *Sun* in one Day, is 12° 11′ 27″ but in her motions, she hath many inequalities, for which purpose, Tables of her motions may be required; I refer you to *Astronomia Carolina*, *Astronomia*, *Harmonica*, *Astronomica Instaurata*, *Tabulæ Britannicæ*, *Astronomia Anglicana*, *Cursus Mathematicus*, *Rudolphus's Tables*, not forgetting Mr. *Newton's*, and Sir *Jonas Moors* Tables; yet amongst them all, the Theory of the *Moon's* motion, remains Imperfect, and not easie to Calculate; many able Mathematicians have writ concerning finding the *Longitude*, by the *Moons* motion: Mr. *Norwood* writ something, but it was never Published; I have been informed, his Method was by the *Moons* motion; concerning which, he writ a large Tract of her motion, and contriv'd an Instrument for taking her distance from fixed Stars. Mr. *Streets* way is unknown to me, but we suppose his way by the *Moons* motion also, by his contriving an *Instrument*, for taking *Angles* by *Reflection*; I have seen

the

the *Instrument*, but he could not bring it to perfection, which I gather from those who have had some Cognizance thereof; see his *Appendix to Astr. Car.* I have seen a Pamphlet writ by *John Herne*, wherein his Method for finding the *Moons Southing*, is very Erroneous, as also, almost all the rest of it; you may believe the like of *Theakers Book*, and *Wooden Tools*; these I mention, that Seamen be not deluded by such Foolish *Tools* and *Pamphlets*. There is a late Author saith, *viz.* find the true Moment of time, in which the *Moon* comes to the *Meridian*, and thereby the *Longitude* of any place may be found after this manner, *&c.* in answer thereto, Sir, I assure you, the *Longitude* is not to be found after your manner, nor by any of your Methods, till better Taught, I presume I know better then your self, what belongs to *Meridian Altitudes*, especially at Sea; and if you please to learn from me, that when the Sun hath South Declination, 20° or 23°; and in North Lattitude, 50 or 60° it is too difficult a matter to find Noon or Mid-day, by any usual Sea Instru-

ment; within two or three Minutes of *time*; our observers commonly begin to observe a little before the Bell strikes Seven, and in the aforesaid Latitudes it is common to observe till a quarter of an Hour past 12 a Clock, before they can perceive the *Sun falling* (as they call it,) but when the Sun is within twelve Degrees of your *Zenith*, then be very quick to attend, or else you may lose your Observation; the like of the *Moon*, or any *Star*; any other time of the Day is more easie and true to be found at Sea, then *Noon*. An Old Experienc'd Navigator pretended to know, how to South the *Moon* by the North Star, on the *Meridian*; I askt him how often he hath seen the *Moon* and North *Star* on his *Meridian*, both at one time, as also how we must do in *South* Latitude, to *North* the *Moon*; and if it were possible to find the time of *Moons Southing* or *Northing*, it is to no purpose, to expect the *Longitude* thereby, considering we can have but one Observation in 24 Hours, besides the Error of accounting her motion in our first *Meridian*; there is no Calculation

lation as yet so exact in any *Almanack* or *Ephemeris*, that tells us the true time of the *Moons Southing*, in any *Meridian* without Error. Mr. *Newton* writes, that from the Error of one Minute of an Hour in the *Moons motion* from the *Sun* ariseth an Error of 7° 12′ in the *Longitude* of the place propounded, and in the motion of the same *Moon*, from any fixed *Star*, riseth an Error of 6° 48′ and moreover (he saith,) it is evident, that if the Errors of both places be not of the same Denomination, and lesser then one Minute of time; the Error of *Longitude* cannot be less then then 13° &c. The *Moons* mean motion being but 13° 10′ 35″ is little in proportion to 360° therefore the two Objections are very considerable; however, as I am a Favourer of the *Longitude*, by the *Moons motion*, I will undertake to solve one Objection, and propose how the other may be solved; then as to the first, I answer, that I know how to find the true time (when we can have Reasonable Observations) of the Day or Night, to one or two seconds of time; and if I Err 4 or 5

 seconds,

seconds, it matters not, others may observe as true as I, if they be careful; in the Practick part of Navigation, it very often happens, that one Error Corrects another, as for Example: Suppose we Err 4 or 5 Minutes in the Lattitude, 2 or 3 Minutes in the Suns R. A. (or Dec. in the Day time,) 3 or 4 Min. in the Stars R. A. and about as many in its Altitude; it is ten to one odds, but these Errors, (if not much greater,) will so help to *Correct* one another, that you will come very near the true time of the Day or Night; and what *Blockhead* will truft to one Obfervation, when he can have the mean of 6 or 8 Obfervations; I account him an Ignorant Obferver, that Errs above 10 or 12 feconds of Time, Day or Night; truft not to Mr. *Seller's*, *Colfon's*, *Norwood's*, *Newton's* Tables of the Suns R. A. for for they fare of no ufe in this cafe. In obferving the time of the Night, be very careful to find the Suns R. A. true, for want of good Tables of the *Suns* place, an R. Afc. Tables of the *Suns* place and *Declination* may ferve, with a little more trouble, for Example,

Anno

Anno 1696, *March* the 29th, at 3^h A.M. 30° to the Westward of our first Meridian; I desire to know the Suns R. Asc. The Tables of the Suns place and Dec. in most *Books* of Navigation, wants Correction; Mr. *Parkers Ephemeris* for this Year, gives the Suns place at Noon, in our first *Meridian*, 9° 44′ ♈ ☉ Dec. 3° 51′ N. but 30° to the Westward, the ☉ place at Noon, will in 9° 49′ ♈ and the ☉ Dec. 3° 53′ N. if you consider the Diurnal difference of the ☉ place and Dec. you will find his place at the time proposed, to be in 9° 27 ♈ ☉ Dec. 3° 44′ N. then having the ☉ present Dec. say, as *Rad.* to *Tang. Comp.* 23° 29′ ☉ greatest Declination, so is the *Tang.* 3° 44′ the present Dec. to the *Sine* 8° 38′ the ☉ R. A. from ♈ at the time and place proposed; but there is a readier way, having found the ☉ place, *Vide, Astr. Car. Tabula Ascensionum Rectarum*, and against the ☉ place, is the ☉ R. Ascention, &c. This Example I thought fit to add for *Seamens* Instructions.

In answer to the second *Objection*, that the Theory of the *Moons* motion is false;

false; it is not long ago since Mr. *Thomas Street* lived amongst us, who said (as I have been informed,) that he was capable to perfect the Theory of the *Moons* motion, so that her place might be as truly found by Calculation, as any of the rest of the *Planets*, if he had Encouragement; 'twas ten thousand pities he had not, but such is our English Ingratitude. There are now living in *England*, two Men, that I believe are capable to perfect the Theory of the *Moons motion*, which if either of them will be pleased to undertake, as also to furnish us with large *Maps* of the fixed *Stars*, such as Dr. *Sprat* is pleased to mention, *Hist.* R. S. p. 190. I may be capable to Practise and Instruct others in the Practick part of *Longitude* at Sea; or the Ingenious may put it to Practice, without my further Assistance. Tables of the *Moons place*, *right Ascension*, and *Declination*, would be pleasing Easie, and more Intelligible to our Seamen, if they be truly Calculated for Noon or Midnight, in our first Meridian: But I think I can find as great Objections, as either of the former;

former; it is very difficult to contrive an Instrument (useful at Sea,) for taking the Moons true distance, from fixed *Stars*, for if you Err but one Minute of motion in the distance, it will produce an Error of about 28′ in *Longitude*; and if the Stars place which you take your distances from, happen to be one or two Minutes false, the Error will be so much the greater; also Idleness is the root of Ignorance, and many other Evils: Our Mathematick *Schoolmasters*, that Teach Navigation, most of their Schollars when they come to Sea, are half to begin again; a Seaman hath much Night work, as well as Day-work, it is convenient to go to School at Nights, to learn to know the *Stars*, how to find the time of the Night by Observation, and how to find the *Moons* place by Observation, I mean to Practice it, for Examples are best Precepts; many able Mathematicians have writ concerning finding the *Longitude* by the *Moons Eclipses*, concerning which, you may find many Examples in *Ph. transf.* of the *Royal Society*, as also in a new *System* of the *Mathematicks*, by Sir

Jonas

James More, in the Doctrine of the *Sphere*, to which I refer you. It is more difficult to find the *Longitude* by an Eclipse of the *Sun*, then of the *Moon*; because that of the *Moon* happeneth at one and the same time, all over the World, but an Eclipse of the *Sun* appears various in the various parts of the Earth; the duration of a Solar *Eclipse*, appears longer in some places of the Earth, then in others, therefore the end of a Solar Eclipse, happeneth not at the same Moment of time, all over the World. The *Superior Planets* suffer no *Eclipses*, when the Earth comes between them and the *Sun*; because the *Conicel Shadow* of the *Earth* cannot reach them.

Anno 1688, *October* the 14th 12° 40′ Mer. dist. West. (plain Chart) from the *Mauritius*, I observ'd the Sun Eclipsed, at the end of the *Eclipse* the ☉ alt. 27° 35′ ☉ Dec. 12° 3′ S. Lat. 31° 6′ S. will give the Hour of the Day, 10ʰ 33′ 48″ A. M. In our first Meridian, the end of the *Eclipse* happened by some Calculations, at 7ʰ 15′ A. M. the difference is 3ʰ 18′ 48″ converted into Degrees and Minutes,

Minutes, gives 49° 41′ *Longitude East*, from our first *Meridian*. The *Penumbra* of the *Moons* Disk, signifies little or nothing; *Astronomers* make more ado about it then needs. *Brother Tar*, have a care of peeping on an *Eclipse* of the *Sun* through a *Telescope*, for endangering the Eye-sight, as I knew one Captain *Norgrave* did: I will tell thee the best way I know for observing Eclipses of *Sun* or *Moon*, take a *Looking-Glass*, set it before thee, so that thou mayest see the *Sun* or *Moon* by *Reflection* on the *Glass*, then with a Perspective, or two or three Foot Telescope, look on the *Looking-glass* for the *Sun*, &c. or you may have smoaked or red Glasses, to save the Eye-sight. That the *Longitude* may be found by the Moons *Eclipsing* any of the rest of the *Planets*, or any known fixed *Stars*, is as certain, as by *Eclipses* of the Sun or Moon. If Mr. *Halley*, was capable to observe the transit of the *Sun* and *Mercury*, as appears by these words, *viz. Situs Solis ad ingressum Mercurii St. Helenæ, Anno* 1677, *Octob.* 28th, 9h 26′ 40″ P. M. surely with ordinary *Telescopes*, we may

be

be capable to observe, when a Star begins to *Culminate* and *Emerge* in (or near) the Moons Disk. Of or concerning Longitude by the *Moons* Approach and Apulses to fixed *Stars*, this some think will be the most Practicable way for Seamen, (yet mentioned) when the Theory of the *Moons* motion is better known. Mr. *F.* hath ingeniously written to this purpose, in his Doctrine of the *Sphere*, Annexed to Sir *Jonas Moors System Mathematicks*, to which I advise you. It is said, that the Moon moveth swifter at New and Full, then at Quarters. To find the Moons place by Observation, the most Ingenious Mathematical way is, by taking her distance from two known fixed Stars; see Mr. *Seller's Practical Navigation*. The *Doctrine* of the *Sphere*, problem 20. but few Seamen understand the Affection and Solution of *Spherical Triangles*, that way is tedious and troublesom; I know Seamen care not to take so much pains, besides the trouble of finding the Moons *Parallax*; and contriving *Instruments* for taking her exact distances from fixed Stars; the Moons place

may

may be found *Geometrically*, by Scale and Compasses; or on large Maps of the fixed Stars; first, knowing her distance from any two known Stars in that Map; but an easier way is, if we could contrive an Instrument to take her difference of *Longitude* from any fixed *Star*, at one distance, which I think not impossible, especially when she is near the *Meridian*, or *Nonagesima*, and then is the best time of Observing. *Illuminatio Lunæ per Solem.* See Mr. *Sellers*, his *Atlas Cœlestis*, in the Figure taken from P. *Gassendi*, *Institutio Astronomia*, *lib.* 2 *cap.* 25. *&c.* The Moon being a round *Body*, and receiving its Light from the *Sun*, it follows, that always one half of it, yea, somewhat more, must be enlightened by him; for seeing that the *Sun* exceeds the *Moon* in bigness, and that the bigger *Spheres* always enlightens above half the less, it does follow, that above one half of the body of the *Moon* must always be Illuminated. And seeing that the *Moon* alters her position, and in running about the Earth, doth variously Face the *Sun*; it must needs be, that according to its

various Acceſs to, or Receſs of the *Sun*, leſs or more of the Illuminated half, will appear to us; which Variations of her appearances, are commonly called her *Phaſes*. The *Moon* is never leſs Enlightened, then when ſhe is at the *Full*, or in oppoſition with the *Sun*; becauſe when ſhe is *Full* only, that part towards us is Enlightened; whereas when *New* or in *Conjunction* with the *Sun*, ſhe is wholly *Illuminated*, that part which is then *toward us*, being Enlightened by the Earth, and the other part that is turned *from us* by the *Sun*. For the *Moon* doth not only borrow her *Light* from the *Sun*, but receives ſome weak *Illuſtration* from the *Earth*; becauſe the *Earth* being an *Opake Body*, muſt of neceſſity reflect part of her received *Light*; and forasmuch as the *Earth* is bigger then the *Moon*, conſequently more *Light* muſt be derived from the *Earth* to the *Moon*, then from the *Moon* to the *Earth*. This is confirmed by Experience, becauſe this *Secondary Light*, as *Galileus* calls it, after the firſt *Quarter*, quite vaniſheth, by reaſon of the *Moons* being

ing

ing too far distant, and without the bounds, to which the reflected *beams* of the *Earth* reach. *Le Grands* body of *Philosophy*, see *Fig.* 30. *part.* 3. *Chap.* 20.

Now if the difference of the Moons *Phases*, or the quantity of her illumination by the Sun, be mensurable by Instrument, then this Method may happen to prove good for finding the *Longitude*. In the *Ph. tr. N.* 29. *p.* 451. is a *Description of an Instrument for dividing a* Foot *into many Thousand parts*, and thereby measuring the *Diameters* of the *Planets*, to great exactness, *&c.* Also see *Ph. tr. N.* 21. *p.* 373. concerning a way for taking the *Diameters* of the *Planets*, and for knowing the *Parallax* of the *Moon*, *&c.* The consideration hereof I humbly recommend to the *Ingenious*, more especially to the *Royal Society* of *London*.

I had almost forgot; I desire you to take Notice, that one good Map of the fixed *Stars*, may serve for *ever*, without Alteration (save that it may decay in time, which bad usage, or a little Alteration of the *Suns* Declination, which

which is scarce worth our notice in one Hundred Years,) provided that either the Equinoctial, or the Ecliptick Line, (in those Maps) be made to slide upon it, and then it is only sliding them a little every *Year*, according to the *Præcession* of the *Æquinox*; the like ought to be considered in *Celestial Globes* and *Planispheres*; also one good Table of the fixed Stars places, may serve for ever, by adding only the Præcession of the *Æquinox*.

CHAP. VII.

Longitude by Jupiter's *Satellites.*

Galileus, in the Year 1610, the 7th of *January*, at the first Hour of the Night, discovered 4 less *Planets* about *Jupiter*, which like so many little Moons are whirled round him. Those of them which are nearest to *Jupiter*, move more swiftly, than those which are more remote. The Revolutions of those *Secondary Planets* are thus Calculated;

culated; the innermost *Satellite*, revolves to the Sun in 1^{d} 18^{h} $28'$ $36''$ so precisely, that in 100 Years, the difference is not sensible; The Periods of the Revolutions of the other Three *Satellites* to *Jupiters* Shade, are as follows.

	d	h	′	″	‴
Period Secundi.	3	13	17	54	3
Period Tertii.	7	3	59	39	22
Period Quarti.	16	18	5	6	50

The Attendants of *Jupiter*, whenever they enter the Verge of his *Shadow*, do suffer an *Eclipse* after the same manner, as the *Moon* doth, when she dips in the shadow of the *Earth*, and are totally depriv'd of *Light*, as being *Opake Bodies*, which borrow their *Light* from the *Sun*. The 3 first of these in every Revolution, produce 4 *Eclipses*; the first, when the *Satelles* enters into the *Rim* of *Jupiter*; the second, when the shadow of the *Satelles*, doth darken the Rim of the said *Planet*; the third, when the upper part of *Jupiter*, at his *Elongation* from us, doth hide the *Satellites*;

tellites; and the 4th, when the *Satelles* dips in the Shadow of *Jupiter*, ſo as that the *firſt Satelles*, within the ſpace of 7 Days, doth effect 16 *Eclipſes*; the ſecond 8; the third, 4; ſo that all of them together, produce 28 *Eclipſes*; the fourth, after that he hath reached the *Nodes*, doth make 4 *Eclipſes* in 17 Days; but when near his bounds, he never ſuffers a defect of his *Light*, becauſe his *Latitude* is ſo large, that he never touches the Rim of *Jupiter*, or reacheth his ſhadow. Theſe *Eclipſes* are of great uſe, in order to the determining of the *Longitudes* of places. *Le Grand's Philoſophy*. But the Eclipſes for our purpoſe, is only the Immerſion or Emerſion of the Satellites, in the Verge of *Jupiters* Shade. Many there are who prefer this *Phenomenon* before others; becauſe the Satellites of *Jupiter* have no ſenſible *Parallax*; and in every poſition of *Jupiter* above the *Horizon*, (in the Night, when *Weather* permits,) are conveniently to be obſerved, with a *Teleſcope* of 12 or 15 Foot long, a fine dancing Inſtrument indeed at Sea, eſpecially in a Gale of

Wind

Wind, (then not manageable,) to look through a *Tube* of 15 or 18 Foot long, which hath only *two Glasses* in it; and I have been troubled at Sea, to find an *Object* with a *Perspective* of 1 Foot and a half long, which hath only *two Glasses* in it; therefore at Sea, for the better finding an Object, we commonly use *Telescopes* with 3 or 4 Glasses in them, of three or four Foot long, (the *Telescopes*) through which I have often looked for *Jupiter*, but never could see his *Satellites* through one of that length; and what must we do for the *Longitude*, when *Jupiter* rises and sets *Cosmically* or *Acronically*, as in *September*, this Year: but we will suppose the best, that the Weather should be so fair, and Sea smooth, that we may possibly get Observations two or three times in a Month, indeed it would be a very great help and satisfaction to us, if the Observations proved good. Mr. *Colson*, an able *Mathematick* Teacher, told me, he had near one Hundred Observation by him, made at Sea, with a Telescope of 6 Foot long, which he contriv'd with a convenient apparatus, for manageing

it. I have one 5 Foot long, in which I have ſeen the *Satellites*; keep your Glaſſes very clean, eſpecially the Object Glaſs, from Miſts or Dews. I deſire to know what we ſhall do for Tables of *Jupiters* Satellites, for Years to come, (always for four Years at leaſt,) Mr. *Parker* in his *Ephemeris*, hath inſerted a Catalogue of the Eclipſes of *Jupiters* Satellites viſible, under the Meridian of the Obſervatory, (I ſuppoſe he means the King's Obſervatory in *Greenwich-Park*,) or near it in the Year 1696. But what muſt they do for ſuch Tables every Year, that are in the Weſt and *Eaſt-Indies*; a late Author in his *Book* Printed *Anno* 1695, hath inſerted two Years Tables for the time paſt, *viz.* 1693 and 1694. borrowed perhaps out of ſome old *Ephemeris*; it is well he ſaid ſomething of the time paſt, its likely he knew little or nothing of what was to come; yet ſome of our able *Aſtronomers* revile and reflect on our Seamens Ignorance, becauſe the Seamen, (as they ſay,) cannot find the *Longitude*, Indeed I think our Seamen have moſt cauſe to rail at our *Mathematicians*, that

that have done nothing, (as I know of,) to any purpose, for the Encouragement or Improvement of Navigation, for almost 20 Years past, (except a *Tide Table*,) as I shall prove by *Seller's Practical* Navigation, the most useful *Book* for Seamen yet extant, and the Impression worse now, then it was almost 20 Year ago; compare the Tables of the Suns place and *Declination*, in the 7th Edition of the *Practical Navigation*, with Tables of the Suns place and Declination in *Parkers Ephemeris*, for this Year, and you will find considerable difference; and that the *Impression* was better 18 or 20 Years ago, I prove by *Pag.* 330, *viz.* A *Table* of the *Variation* of the Suns *Declination*, to be applied for Years to come, &c. If the *Tables* were the same, as in *Anno* 1680, or thereabouts, we might by the said Table of *Variation*, have Corrected the Tables of the *Suns Declination*, but there is imposed on us, new dates of Years, *&c.* The aforesaid *Book* wants Correction very much; there is wanting in it a larger *Table* of difference of *Latitude* and *departure*, such a one as is

in *Colson*'s *Kalendar*; the Tables of the Suns *right Ascension*, ought to be more large, and Calculated to Degrees and Minutes, to a certain Year, &c. Pardon this *Digression*, now to our purpose again; since we are unfurnished with fitting *Tables* of all the said *Satellites*, I recommend you to the best I know of, *Viz.* See *Phil. Trans. N.* 214 *p.* 237. to 256. *Monsieur Cassini*, his New and Exact Tables for the *Eclipses* of the first Satellite of *Jupiter*, reduced to the *Julian* Style and *Meridian* of *London*, &c. But in Calculating the Eclipses of the Satellites by the said Tables, there sometimes happens an Error of 3 or 4 Minutes of Time, I believe I know how to Correct that Error, (though it hath baffled the Ingenious,) and would a done it here, if it had not required Figures or Guns for Demonstration. *Saturn* hath also five Satellites attending him, but are not accounted so worthy our notice for the *Longitude*, as the former, therefore I pass them in Silence.

The Sun, *Jupiter*, and all the rest, (except the *Moon*,) of the *Planets*, have a Circumrotation in their own proper

Vortex,

Vortex, as *Teleſcopial* Obſervations teſtifie, by ſeveral ſpots that appear in their *Phaſes*. Perchance it may be ſaid, why have not I furniſhed this Book with regular *Tables* of the *Moons* motion, and of *Jupiters* Satellites: It would be a very unreaſonable demand to require them from a Man that hath wanted both *Books* and *Inſtruments*, (till now) alſo conveniencies and opportunities, having only a ſmall Cabbin, ſometimes not high enough to ſtand upright in, nor my length to lie down in; inſomuch, that I have been obliged to borrow both *Books* and *Inſtruments*, for the common Practice of *Navigation*, beſides the Circumſtances of my Imploys, and many other Inconveniencies, that might and did attend ſuch Studies and Obſervations. I will conclude this Chapter with the following words, which I take to be the Ingenious Mr. *Flamſtead's*, *viz.*

As by *Lunar Eclipſes*, ſo alſo by the Eclipſes of *Jupiters* Satellites, the difference of the obſerved Moments of the Occultation or Emerſion of a Satellite from his ſhadow, noted carefully in two

distant places, will be the difference of Meridians, betwixt these two places in time; but I cannot hope that this Method shall prove of much use to the Ingenious Seamen, because the Observations require long *Telescopes*, which in a Ship will hardly be manageable; nor can we expect to find the difference of Meridians, by one only Observation of a Satellite Eclipse, as we have hopes we may by a *Lunar*, by reason that as yet, the inequality of their motions, and the time required for the transmission of Light from the Planet to our Earth are unknown; nay, their mean motions are scarce so exactly stated, but that we may justly suspect them Erroneous; omitting these therefore, the best Method for the discovery of the *Longitude*, will be in my Opinion, (I am dubious, he is now of another Opinion,) by the Moons Apulses to, or observed distances from fixed Stars, upon which Accoun I would recommend the Improvement and Correction of her Theory, with the Doctrine and Construction of Apulses, to the Study of the Ingenious Astronomer and Seamen.

Huma-

Humanum eſt Errare, I had almoſt forgot, Mr. *Newton* hath contriv'd an Inſtrument for his own uſe, to ſee *Jupiters* Satellites by reflection, on well poliſhed Mettle; the Inſtrument is about 15 Inches long, as ſome ſay, other 9 or 10 Inches, and call it a reflecting Teleſcope; I am informed it is of little or no uſe. I have not ſeen any of them, therefore can give you no better Deſcription. I alſo add, To tell ſome Maſters of ——— of *Jupiters* Satellites, is like telling a Story to a Bear; they know better how to manage a Cann of Philip. The ſetting and well-manageing a Teleſcope, is of great Conſequence.

CHAP.

CHAP. VIII.

Concluſion.

OMnia probate, quod bonum eſt tenete, That which I have written in this *Book*, I deſigned for the publick good of Mankind: in which I hope I have not offended God. If any Arts or Sciences, Commerce or Trade, be Good and Juſt in their kind, then what I have writ concerning *Longitude*, is Good and Juſt in its kind: that is, if it be not Abuſed: Though there was an Officer in the *Navy*, (as I was informed,) who Curſed and Damn'd the Man that ſhould diſcover the *Longitude*; thou Old, Inveterate, Ruſty, Muſty, Filthy, Cankered, Carnal Devil, for Curſing down upon thy Marrow-bones, (if thou haſt any,) and ask God Almighty forgiveneſs for thy Sins, know that it it is not in thy Power to Damn any Man but thy ſelf: God who ſuffered the Earth to be Inhabited by Angels,

for

for an infinite number of Ages, before he Created *Adam*, and then expelling them hence for their Wickedneſs, and turning them to Devils, gave this Globe for a dwelling place to Men; grant that the enormous Crimes of Mortals, may not provoke him to Exterminate our Humane Race, and reſtore the Devils to their Antient Habitations, *Tat. Spy. Vol.* 3. *Pag.* 359.

But as for that one Man, (I doubt there is more ſuch,) aforeſaid, I believe he did not ſpeak it then out of Ill-will to me, but to ſome other Perſon, or rather raſhly or unawares; I believe his meaning at that time was, that this ungrateful World did not deſerve ſo great a Bleſſing, or ſo worthy a Science. I am thinking what my Country will be pleaſed to ſay of me, if they call me *Aſtrologer*, I give very little Credit to *Judicial Aſtrology*, nor do I profeſs any ſuch deceitful lying Arts; if *Magor*, its an Expreſſion for *Fools*, and their bolt is ſoon ſhot; if *Star-Gazer*, I anſwer, a *Star-Gazer* is better then a *Booby*; ſome may Envy me, ſome Laugh and Scoff at me, (a common

Method

Method to ſolve their own Ignorance,) others Mock and Ridicule me; ſo our Predeceſſors did at *Columbus*, when he came hither to offer them the diſcovery of the World, and ought not they to have been Recorded for F——s, as (ſome ſay,) the *Pope* was, that *Anathematiz'd* the *Biſhop* of *Straſburg*, for writing of *Antipodes*. But now I think on't, I have a reſerve which they are not like to know yet a while. As I have heard ſay, the *Venetians* have offered Rewards; the States of *Holland* (as I was informed,) ſome Years ago, took this Science ſo much into their Conſideration, that they offered Ten Thouſand Pounds, to any Man that was capable to diſcover it; *Thomas Axe*, an Engliſhman, left a Legacy of One Thouſand Pound, (never to be paid I think,) to any Perſon that ſhould diſcover the *Longitude*, within the ſpace of Ten Years after his Deceaſe, if his Wife and Child died Childleſs in that time; beſides, it is to be approved of by the four Profeſſors of Geometry and Aſtronomy, in *Oxford* and *Cambridge*, for the time being, and at leaſt twenty Experienc'd

Maſters

Masters of Ships, that shall have made several Experiments thereof in long Voyages. Affidavits are to be made before the Twelve Judges of *England*, &c. He dyed in the year 1691, and I think took care enough, that the said one Thousand Pound should be Irrecoverable; indeed, I have little better Opinion of either the *Venetian* or *Dutch* Gratuities; States may be mistaken in their Policies; God Almighty never ordained that this Science should be well known to the World, by fraudulent means, but if their designs be real, (as you may suppose,) where is the Encouragement? I know not how to recover my Cost and Charges, though I have laid (and shall the rest by and by,) most of the ground work at my Charge; where is the Money to raise and perfect the Work? There is - —— Pounds wanting, present Pay, towards the Charge of making two wonderful Instruments, for the first making of the Instrument, will be very Chargeable; one of them may prove far more chargeable then the other, and yet when it becomes common, it may be sold at

a low Price, I Judge under fifty Shillings; yet before the *Instrument* can be brought to such Perfection, as to shew two or three *Examples*, may cost several Hundreds of Pounds, and for ought I know, take up most part of a Year, to accomplish them; it is an *Instrument* that must be truly Cut and Polished, a small matter of a false sweep or stroke may quite spoil it, and make it good for little or nothing; therefore one Hundred of them may happen to be spoiled before we can get the right Art of making them; neither of them will suddenly be fit for Seamens Practise, because the *Natural motions* that one of them is to shew, are at this present writing, I believe, unknown to the World; therefore reasonable time is required to Calculate the *Theories* of those *motions*. I will give you a brief Description of one of the *Instruments*, it is one or two, I know not well which to call it, it is round, its Diameter about 8 or 10 Inches, may be a good size, it is not altogether *flat* nor *Convex*, nor *Concave*, nor *Globular*, it contains several Circles exactly swept even, to a Hairs

breadth

breadth, the *Areas* of each Circle, muſt have their juſt proportions, but have no viſible point for a Center, nor are the Circles Cut and raked in its *Surface*, but ought to appear above it; it hath no ſtraight Lines, ſave only in its *Frame* of —— which muſt be divided into 360 Deg. and ſubdivided, *&c.* it is *Scioptrick, Dioptrick, Catoptrick*, P. —— S. —— K. and P. —— H —— K. and whereas moſt Secrets ſeem moſt wonderful before they are diſcovered; this Inſtrument will ſeem moſt wonderful, when the beſt *Deſcription* is given of it, and when put to common uſe; to give a true and perfect Deſcription of its ſecret properties, like the *Loadſtone*, may puzzle the *Oxonian Sophiſt*, or Pariſian *Sorboniſt*; but this I give for one *Aphoriſm, Natura nil agit fruſtra*; I hope it may anſwer our deſigns in the *Longitude, niſi Argentum agit fruſtra*; but all is in the Power of God; it is an Emblem of *Trinity, Trinity* in *Vnity*, and *Vnity* in *Trinity*. Indeed I have but little more Knowledge of it, then is in the Idea of my Brain, for the Experimental part is moſt wanting, but

the

the World may believe, that I can produce ſound Principles and Evinceing Arguments for my Opinion, elſe I ſhould not have made it ſo publick; delays are dangerous, *Ars longa, Vita brevis*; but if it pleaſe God, I ſhould be glad to live to ſee this Art come to ſuch Perfection, as to be fit for Seamens Practice, during the natural Courſe of my Life. *Reader*, believe if you pleaſe, that he that writ this, could a writ more, and more to the purpoſe, if he would; I think it enough for five or ſix Weeks Time and Study, and abundance too much, if for a Gratuity, I may ſuck my Paw, or only my labour for my Pains; future Ages may be more Competent *Judges*, but my Mind will be eaſier when this Book is Publiſhed, becauſe therein I have done my Duty, and eaſed the burden of my Brain. If in this *Treatiſe* I have ſeemed to reflect on any Perſon, it is my *Dialect*, I deſire their Excuſe; I Envy no Men: Envy and Ingratitude, is moſt natural to ſome, whoſe Duty it is to underſtand theſe things and their Capacities, cannot reach them. If any

Perſon

Perſon is minded, or can, or will undertake to Correct or Amend what I have writ, I wiſh them good ſucceſs; I deſire them to own what they borrow, and not to reflect without juſt cauſe; it is difficult to write ſuch a *Book* as this is, (I think it is the firſt of this nature,) without Faults; it is likely I my ſelf may find ſome in a Years time, that if I were to write over again, I could amend; I dare affirm, that this Book contains ſome eſtimable Expreſſions and Methods, fit for Seamens Knowledge and Practiſe, and ſuch as have not been formerly Publiſhed; there are ſome Perſons in *England*, whoſe Duty it is (being paid for it,) to improve *Navigation* and *Aſtronomy*, and from whom much is expected, and little or nothing of purpoſe appears.

It is my Opinion, that the appearances of Comets may be found by Calculations, if any Perſon capable, think it worthy his trouble. Concerning this Book, the common Vogue will be, *viz. but will it do*, is it the *Longitude*, I ſay? Yes, it is the *Longitude* begun, and will do with *Induſtry* and *Encouragement*,

else not; for it is contrary to *Seamens* Vulgar sayings, that when the *Longitude* is found, then there will be abundance of *Artists*, Navigation will be so easie: No, no, Navigation will not be so easie at present, but much more certain and true. The Learned *Bacon* said, the *Longitude* was worth a Kingdom to a Wise Man; but before I conclude, to return to my *Instrument*, the Description I have given thereof, availeth little, without my further assistance; till then, the Reader if he pleaseth may compare ——— to *Foxes* staring on Bunches of ripe *Gripes*, and cannot get at them; then they are too sowr for them: for so my *Dream* intimateth, when I was among a Crowd of *Foxes*, aw'd at my Presence, and after I had looked on them, they vanished, and left me other Objects. The most Ingenious of Humane Inventions, is far less facile then the ordinary performances of Truth and Nature. I love my King, the Church of *England*, and my Country, and I thank my God, I know my self capable and worthy to serve them, though too much debased

for

for want of Friends in Court. If this meet with its deſerved Encouragement, the reſt may follow in good time; but I muſt make haſte and conclude, my attendance and dependance being required in our *Navy Royal*, which Duty, I dare not neglect, for fear of being *Excommunicated*, or which is as bad, Excluded from Preferment. *Quamvis bene merenti.*

Nil tam difficile eſt quod non Solertia Vincat.

Te Deum Laudamus.

F I N I S.

ERRATA.

Page 2. *l.* 9. *r.* plane. *p.* 17. *l.* 8. *r.* Zulichem. *p.* 20. *l.* 6. *r.* certis. *l.* 9. *r.* Induſtria. *l.* 19. *r.* an Idea. *p.* 28. *l.* 3. *r.* Bond. *p.* 29. *l.* 5. *r.* the encreaſe. *p.* 30. *l.* 3. *for* me, *r.* one. *l.* 17. *for* by, *r.* with. *p.* 31. *l.* 22. *r.* though. *l.* 23. *r.* ſuppoſe. *p.* 36. *l.* 12. *add* when Northerly. *p.* 37. *l.* 10. *r.* preceding. *p.* 59. *l.* 27. *for* P. M. *r.* A. M. *add* Schema Solis ad Eximum Mercurii, St. Hellene, *Anno* 1677. Octob. 28. 2 h. 4′ P. M. *p.* 55. *l.* 10. *r.* will be. *p.* 63. *l.* 27. *r.* with. *p.* 70 *l.* 2. *r.* Sun and Stars.

for want of Friends in Court. If this meet with its deserved Encouragement, the rest may follow in good time; but I must make haste and conclude, my attendance and dependance being required in our *Navy Royal*, which Duty, I dare not neglect, for fear of being *Excommunicated*, or which is as bad, Excluded from Preferment. *Quamvis bene meremti.*

Nil tam difficile est quod non Solertia Vincat.

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Page 2. l. 9. r. plane. p. 17. l. 8. r. Zaikhem. p. 20. l. 6. r. certis l. 9. r. Industria. l. 19. r. an Idea. p. 28. l. 3. r. Bond. p. 29. l. 5. r. the cereale. p. 30. l. 3. *for* me, r. one. l. 17. *for* by, r. with. p. 31. l. 22. r. though. l. 21. r. suppose. p. 36. l. 12. add when Northerly. p. 37. l. 10. r. preceding. p. 39. l. 27. *for* P. M. r. A. M. add Schema Solis ad Exitum Mercurii, St. Hellene, *Anno* 1677. Octob. 28. 2. h. 4' P. M. p. 55. l. 10. r. will be. p. 63. l. 27. r. with. p. 70. l. 2. r. Sun and Stars.